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# The Formation of Chitosan Fiber by UsingDifferent Solution Formulation

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**Abstract**: Spinning is one of the methods drawing out fibers or filament and twisting together to form a yarn in textiles. Nowadays, spinning involves many methods with different technique and equipment. The production of chitosan fibres involves a mixture of several solvents to become solution. The compatibility of the solvent with the base polymer and the coagulation bath during the chemical reactionare crucial. The main objective of this project is to investigate the formation of chitosan fiber by using different solvent of chitosan solution and different coagulation bath. The formulation of the chitosan solution is divided by 8 different testing samples. The experiment for the formation of fiber will be conducted with wet spinning method where the fiber-forming method that involves dissolving the polymer in the solvent and extruding the solution into a chemical bath. The results for all of the 8 testing sample formulation ending with the formation of fibre in 10 seconds and dissolve in the coagulation bath solution.

**Keywords**: Wet Spinning, Chitosan, Sample Formulation

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## 1. Introduction

Chitosan is a copolymer composed of glucosamine and N-acetyl glucosamine derived from chitin. As mentioned in various stunning assessments, chitosan is becoming a versatile raw material for the synthesis and production of a wide range of commodities, with applications in food, medical, pharmaceutical, health care, agricultural, industry, and pollution control. Because of the reactive amino and hydroxyl groups, chitosan exhibits various functional properties, including polyelectrolyte, antibacterial, antioxidant, gel-forming, biocompatibility, metal chelating, and simplicity of processing.[1]. Because of the hydrogen bonds and intramolecular between the chain segments, chitosan is insoluble in water. Due to the existence of non-bonding pairs of electrons in the amino groups, which get protonated in acidic solutions, it may be easily dissolved in dilute acidic solutions such as aqueoussolutions of acetic acid, citric acid, lactic acid, malic acid, and formic acid. The solubility of chitosan in ecologically favourable and low-cost solvents is a significant benefit in the production of chitosan- based fibres. [2].

### 1.1 Properties of chitosan

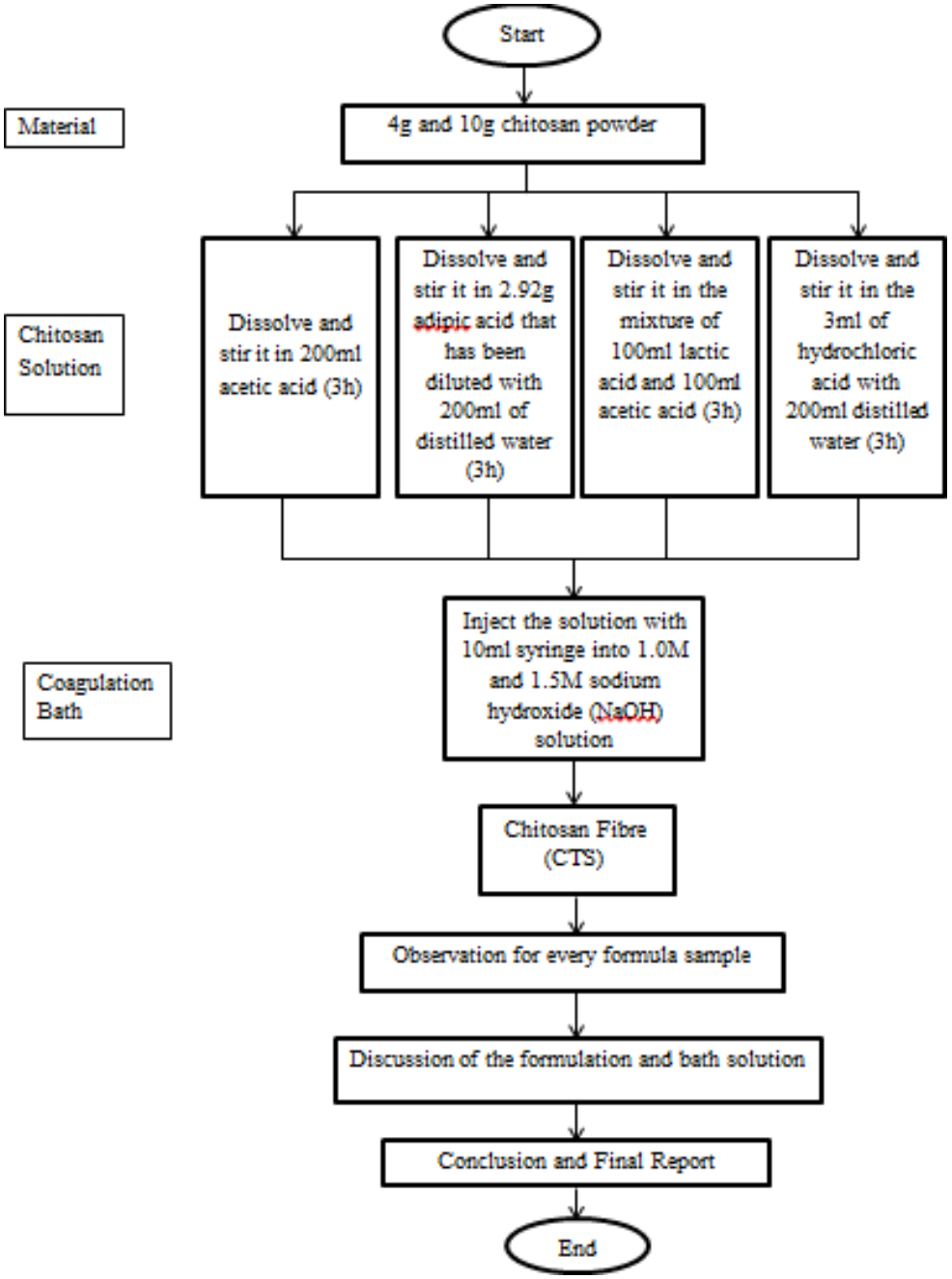
This biopolymer is excellent for a variety of biological applications due to a number of its chemical characteristics. Chitosan is a N-acetylglucosamine linear homopolymer composed of -(1,4)-linked units. It is a partially deacetylated polymer produced by basic deacetylation of chitin, an unbranched glucose-based polysaccharide found in the exoskeletons of crustaceans, insects, and some bacterialand fungal cell walls. The origin, separation, and level of chitin deacetylation all affect the quality of chitosan. A few of the biological properties of chitosan include nontoxicity, hemocompatibility, biodegradability, anticancer, antioxidant, and antibacterial properties.

### 1.2 Wet Spinning Process

Wet spinning is a fibre-forming method that involves dissolving the polymer in a solvent and extruding the solution into a chemical bath. It is a time-honoured method for creating polymer-based textiles. A polymer-based solution is fed via a syringe into the coagulation or cross-linking solution using a syringe pump in the wet spinning process to generate continuous fibres. Depending on the polymer properties, the coagulation or cross-linking solution contains a non-solvent and/or a poor solvent. [3]

## Materials and Methods

### 2.1 Flowchart of Research Methodology



## 2.2 Materials

200g of chitosan (CTS) powder have been purchased from China. This powder will acts as a base polymer for the spinning solution. There are 4 different solvent use in the CTS solution which are acetic acid, lactic acid, hydrochloric acid and adipic acid. This acid have been purchased from 'Syarikat Saintifik Bersatu M Sdn Bhd' at Batu Pahat, Johor together with ethanol that act as a dewatering and washing solution for wet spinning process.

## 2.3 Preparation of CTS solution

4% chitosan solutions were prepared by dissolving 4g and 10g chitosan powder into 8 different formula samples with different solvent. The solvent is 4 type different of acid which is acetic acid, lactic acid, adipic acid and hydrochloric acid. The formula samples are shown in Table 1.

**Table 1: Sample formulation of Chitosan Fibre**

| Sample Formula | Mass of the powder | Solvent |
|---|---|---|
| 1 | CTS Powder (4g) | Acetic Acid 200ml |
| 2 | CTS Powder (8g) | Acetic Acid 200ml |
| 3 | CTS Powder (4g) | 2.92g Adipic Acid +200ml distilled water |
| 4 | CTS Powder (8g) | 2.92g Adipic Acid +200ml distilled water |
| 5 | CTS Powder (4g) | 100ml Acetic Acid+ 100ml Lactic Acid |
| 6 | CTS Powder (8g) | 100ml Acetic Acid+ 100ml Lactic Acid |
| 7 | CTS Powder (4g) | 3ml 0.1M Hydrochloric Acid +200ml distilled water |
| 8 | CTS Powder (8g) | 3ml 0.1M Hydrochloric Acid +200ml distilled water |

## 2.4 Preparation of Coagulation Bath

In wet spinning process, the base polymer had been dissolved into the solvent which three type of acidhas been used including acetic acid, lactic acid, hydrochloric acid and adipic acid. Then the solution had been extruded into a coagulating bath with the diameter 0.8 mm and length 25mm needle that has been attached to the 10ml syringe. Two different coagulation baths were prepared, including 1.0M of sodium hydroxide solution and 1.5M NaOH solution as shown in Table 2 below.

**Table 2: Preparation of sodium hydroxide solution**

| Concentration of solution (M) | Amount of NaOH Powder (g) |
|---|---|
| 1.0 | 40 |
| 1.5 | 60 |

The first step for the preparation of sodium hydroxide was fill the distilled water into 1000ml beaker. Measure the mass for the sodium hydroxide pellet until it weighs to 40g for 1.0M concentration and 60g for 1.5M concentration of the solution. Put the sodium hydroxide pellet into the distilled water and stir it continuously for 5 minutes until it dissolves in the distilled water.

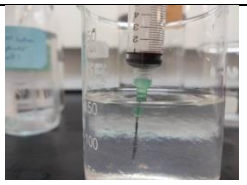
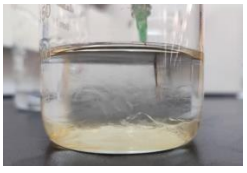
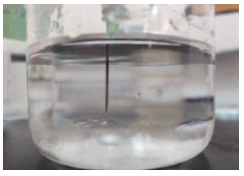
## 3 Results and Discussion

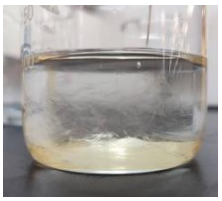
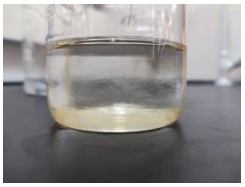
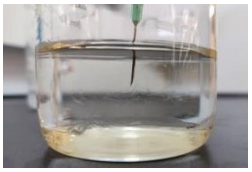
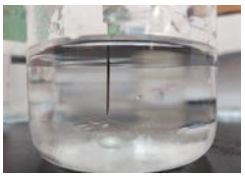
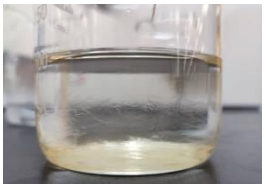
The results of the 8 testing sample formulation of chitosan solution that have been injected into the coagulation bath with the syringe and the needle 0.8mm diameter and length 25mm attach to it is not going well because the fiber that have formed for 10 seconds dissolve and the disperse in thecoagulation bath.

### 3.1 Results of the Wet Spinning

Every solution for spinning process has its own special properties as shown in Table 3. The formation structure for the every fibre formed not only depends on the processing condition, but also depends for the type of solvent used and the coagulation bath concentration and composition.

**Table 3: Result for every testing sample**

| Testing Sample | Coagulation Bath | Result |
|---|---|---|
| S1 | 1.0M solution of NaOH |  |
| S2 | 1.5M solution of NaOH |  |
| S3 | 1.0M solution of NaOH |  |

| | | |
|---|---|---|
| S4 | 1.5M solution of NaOH |  |
| S5 | 1.0M solution of NaOH |  |
| S6 | 1:.5M solution of NaOH |  |
| S7 | 1.0M solution of NaOH |  |
| S8 | 1.5M solution of NaOH |  |

For sample 1 and 2 which acetic acid had been used as a solvent for the chitosan solution, the output that has been produced out from the syringe with the needle attach to it that had diameter 0.8mm in the coagulation bath solution is in liquid form. Before this, a needle with 0.5mm had been used for theprocess unfortunately the chitosan solution cannot come out from the syringe when the piston had been pushed onto it. The chitosan fibre produced in 5 to 10 seconds then dissolve in the coagulation bath. All the testing sample of the chitosan formulation produce a liquid form that turn into colorless fibre and then disperse within the bath solution. From the observation, the absent of the cellulose content in the chitosan solution had make the mechanical structure of fibre decrease and effect the formation of the fibre. The cellulose content is used to alter the mechanical properties of the fibresand strengthen it. Cellulose is the most abundant organic compound on earth with chemical formula $C_6H_{10}O_6$.

## 4 Conclusion

This project has been carried out to compare and analyze the morphology of the chitosan fiber formedwith the past research by the different coagulation bath. Unfortunately, the result did not go well where the fiber was formed for 5 to 10 seconds and just dissolved in the coagulation bath with all of the 8 type formulation of chitosan solution sample that have been created. Although, there was no analysis for this project because the chitosan fibre is not formed, the future research can try this setup with the proper equipment and accurate measurement.

## Acknowledgement

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